Elsewhere I have shown that the particular integrating factor given by

$$\left.\begin{aligned} pV &= \frac{1}{\mu} \\ \text{with } \mu &= f(U) \end{aligned}\right\} \quad \ldots\ldots\ldots\ldots\ldots\ldots (30)$$

leads to a consideration of a new type of cycle analogous to that of Carnot. The new cycle comprises two adiabatics and two iso-U curves instead of two isothermals.

CRYSTALLOGRAPHY.—*The crystallography and optical properties of β-lactose.*[1] EDGAR T. WHERRY, Bureau of Chemistry and Soils.

Although the crystallographic features of ordinary α-lactose have been fully described, there appear to be no data on the β-form. In the study of the development of minute crystals of sugars in ice cream, the Bureau of Dairy Industry of the United States Department of Agriculture found it desirable to have means for distinguishing these two forms of lactose from one another as well as from sucrose, and the examination of the grains by the immersion method under the polarizing microscope seems well adapted to the purpose. Accordingly O. E. Williams of that Bureau prepared and turned over to the writer a sample of crystallized β-lactose, in order that its properties might be determined and contrasted with those of other sugars. The crystals were obtained by holding a concentrated lactose solution at a temperature of about 94°C. They were then washed several times with hot glycerol and hot ethanol. The melting point was found to be 252.4°C.; since the melting point given in the literature is 252.2°, their identity was thus confirmed.

The crystals, which range from 1 to 5 mm. in diameter, are transparent and colorless. They have a pronounced polar development, and the distribution of their faces show that they belong to the holoaxial-polar (sphenoidal) class of the monoclinic system. Measurements of 10 crystals were made on the two-circle goniometer, with the results presented in Table 1.

[1] Received March 19, 1928.

TABLE 1.—ANGLES OF β-LACTOSE

Monoclinic, holoaxial-polar; $a : b : c = 0.817 : 1 : 0.377$; $\mu = 88° 15'$

No., letter	Symbols		Description	Angles			
				Measured		Calculated	
	Goldschmidt	Miller		φ	ρ	φ	ρ
1.*c*	0	001	Prominent but distorted	80°–85°	1° 45′	90°00′	1°45′
2.*m*	∞	110	Dominant, reflecting well	50° 45′	90° 00′	50°45′	90°00′
3.*L*	−2 ∞	$2\bar{1}0$	Prominent, much curved	65°–75°	90° 00′	67°46′	90°00′
4.*X*	$-1-\frac{2}{3}$	$\bar{3}\bar{2}3$	Moderately curved	58°–60°	25°–27°	59°44′	26°29′

For the most part the faces are more or less rounded, but the angles could be measured with sufficient precision to make the second decimal place certain, so that the axial ratios are stated to the third place. The form having the most nearly perfect faces was taken as the positive unit prism, and used for orienting the crystals on the goniometer. The value of the acute monoclinic angle μ (often called β by American crystallographers, although this symbol more properly belongs to the obtuse angle) was then obtained by measuring the ρ angle of the principal terminal plane, which was taken as the basal pinacoid. To obtain the axial ratio *c* it was necessary to use measurements on a distinctly curved form, so that the value of this axis is especially uncertain. That form was taken to be a negative back pyramid, and the symbol for it which gave the most reasonable value for *c* was found by trial to be $(\bar{3}\bar{2}3)$. Figure 1 shows the habit, the plan at the top having been drawn with straight edges in the theoretical positions, the parallel-perspective elevation below with the edges in part curved as they are in reality.

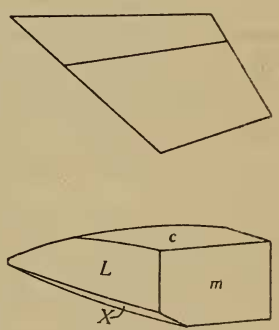

Fig. 1

When examined by the immersion method under the polarizing microscope, the substance appears in irregular fragments, showing between crossed nicols first to third order colors, and yielding on trial with successive liquids the refractive index values: $\alpha = 1.542$, $\beta = 1.572$, $\gamma = 1.585$. As the positions of the grains are random, means of these values are usually exhibited, although it is not difficult to find grains with the different index directions lying horizontally, so that matching with the corresponding liquids can be obtained. In convergent polarized light negative biaxial interference figures having a rather large axial angle, $2E = 120°$, are occasionally obtained, the

axial plane lying in the ortho-zone, and the acute bisectrix lying in angle μ about 30° from axis c. Table 2 shows these values, contrasted with those of α-lactose and sucrose.

TABLE 2.—Optical Constants of Three Sugars

Substance	α	β	γ	$2E$
α-lactose	1.517	1.553	1.555	$33\frac{1}{2}°$
β-lactose	1.542	1.572	1.585	120°
Sucrose	1.540	1.567	1.572	79°

The reason that the refractive indices of the β-lactose are so much higher than the corresponding ones of the α-form is that the former is anhydrous, whereas the latter is a monohydrate. The value of β given for α-lactose represents a redetermination, and accords with the small axial angle better than the value usually ascribed to this substance. In all three cases, however, β is less certain than are the other two indices, because of the random positions assumed by the grains.

For distinguishing these three sugars in practice the procedure given in Table 3 may be used. Oily immersion liquids of refractive indices 1.520, 1.540, 1.555, 1.570, and 1.585 are required. All observations should be made on grains brought to an extinction position by rotating the stage until the grain attains its maximum darkness as viewed between crossed nicols, and then removing the upper nicol (analyzer). The rule for ascertaining the relative values of the refractive indices is simply that on *raising* the microscope-tube slightly a band of light is seen to pass into that substance—crystal or liquid—having the *higher* index in the direction of the vibration plane of the polarizing nicol. In making such observations in white or yellowish light, the ordinary eye is unable to distinguish differences in refractive index between two substances in contact less than about $\pm$ 0.003; apparent matching means, then, that the index of crystal and liquid agree with this degree of approximation.

TABLE 3.—Directions for Distinguishing α-Lactose, β-Lactose, and Sucrose

Immerse in liquid 1.520. If the boundaries of numerous grains disappear, repeat with liquid 1.555; if this is also matched by a number of grains the substance is .....α-lactose.

In case the refractive indices of the grains are all decidedly higher than the first liquid, try liquid 1.540. If this matches the lowest index of some grains, repeat with liquid 1.570; if some grains match this and none show a higher value, the substance is .....sucrose.

If one refractive index on many grains proves to be distinctly higher than the last liquid tried, immerse next in liquid 1.585. If this matches the highest refractive index of any of the grains, the substance is.....β-lactose.

Should none of these requirements be fulfilled, the substance under examination is neither lactose nor sucrose.

GEOLOGY.—*A new locality for Fox Hills fossils in Colorado.*[1] J. HARLAN JOHNSON, Colorado School of Mines (Communicated by JOHN B. REESIDE, JR.).

In August, 1926, the writer discovered a new and rather prolific locality for Fox Hills fossils that seems worth recording because of the fine preservation and unusual variety of forms present. It is located in secs. 21 and 22, T. 11 N., R. 68 W., southeast of Round Butte and about 12 miles north of the town of Wellington in Larimer County, Colorado.

The fossils occur in a relatively thin zone at about the base of the Millikin sandstone member, as defined by Henderson.[2] The stratigraphic section at the locality is as follows:

SECTION OF PART OF THE FOX HILLS SANDSTONE IN SECS. 21 AND 22, T. 11 N., R. 68 W., LARIMER COUNTY, COLORADO.

Bed		*Fee*
8.	Sandstone, greenish yellow, massive though rather soft	25
7.	Sandstone, white, containing many small limonite concretions	9
6.	Sandstone, soft, massive, white with light brown streaks; some buff concretions near base	18
5.	Sandstone, hard, dark brown	1
4.	Sandstone soft, massive, white; contains irregularly scattered concretions as much as 4 feet in diameter	12
3.	Sandstone, soft, buff; contains brown concretions of varying size	15
2.	Shale, brown, sandy, with much concretionary limonite in small masses	4
1.	Shale, dark gray to black, slightly sandy	?

Most of the fossils collected came from beds 5 and 6. There were also, in bed 4 and bed 6, sandstone casts of pelecypods, sometimes showing remnants of the shell, but usually in a poor state of preservation. No fossils were noted in beds 1, 2, or those below the measured section. The best preserved specimens came from concretions in bed 4, though a number of well preserved fossils came from other concretions at the base of bed 6.

The fauna of the locality, as determined by John B. Reeside, Jr., of the U. S. Geological Survey, is as follows:

Pelecypoda: *Callista nebraskensis* Meek and Hayden, *Cardium speciosum* Meek and Hayden, *Gervillia subtortuosa* Meek and Hayden, *Mactra formosa* Meek and Hayden, *Modiola meeki* Evans and Shumard,

[1] Received March 13, 1928.

[2] JUNIUS HENDERSON. Colo. Geol. Surv. Bull. **19**: 22. 1920.

Nucula larimerensis Reeside,[3] *N. weldensis* Reeside,[3] *Ostrea gillulyi* Reeside,[3] *Ostrea* sp.?, *Protocardia subquadrata* Evans and Shumard, *Pteria nebrascana* Evans and Shumard, *Teredo?* tubes, *Veniella humilis* Meek and Hayden.

Scaphopoda: *Dentalium gracile* Hall and Meek.

Gastropoda: *Anchura americana* Evans and Shumard, *Cylichna volvaria* Meek and Hayden, *Fasciolaria* (*Piestocheilus*) *scarboroughi* Meek and Hayden, *Fasciolaria* sp., *Fusus* (*Serrifusus*) *dakotensis* Meek and Hayden, *Fusus?* sp., *Gyrodes johnsoni* Reeside,[3] *Haminea subcylindrica* Meek and Hayden, *Lunatia occidentalis* Meek and Hayden, *L. subcrassa* Meek and Hayden, *Pyropsis bairdi* Meek and Hayden?, *Pyropsis* sp., *Trachytriton vinculum* Hall and Meek.

Cephalopoda: *Discoscaphites conradi* Morton.

Associated with the invertebrates were shark teeth, small vertebrae of fish, and silicified wood, in part showing the effects of attack by boring mollusks.

PALEONTOLOGY.—*New Cretaceous mollusks from Colorado and Utah.*[1]

JOHN B. REESIDE, JR., U. S. Geological Survey.

This paper describes three species of pelecypods and a gastropod from the Fox Hills sandstone (Maestrichtian) of northeastern Colorado and a gastropod from the base of the Colorado group (lower Turonian) of Utah. The geographic location, stratigraphic position, and faunal association of the Fox Hills species are described above by Professor J. Harlan Johnson (pages 305–306).

Genus NUCULA Lamarck

Nucula larimerensis Reeside, n. sp.

Figures 7–9

A single specimen from the Fox Hills sandstone in sec. 21 or 22, T. 11 N., R. 68 W., Larimer County, Colorado, collected by Prof. Johnson, is the basis of this species.

Shell moderately large, heavy; broadly subelliptical, moderately gibbous; proportion of length to height about as 5 to 3. Beaks blunt, subcentral. Lunule and escutcheon but little differentiated. Posterior margin narrowly rounded, anterior margin a little broader; basal margin gently convex, crenate inside. Dorsum declining with very slight convexity both before and behind the beaks; gross angle formed by the dorsum at the beak of the valve 130°.

[3] See pages 306–312 for description of these species.

[1] Published by permission of the Director of the U. S. Geological Survey. Received March 13, 1928.

Sculpture consists of fine, irregularly spaced concentric lines of growth; and very faint radial lines scarcely visible without the assistance of a hand lens, 2 per millimeter at the posterior margin and 3 in 2 millimeters at the anterior margin.

Hinge and other internal characters not seen.

Length, 35 millimeters; height, 22 millimeters; convexity of a valve, 8 millimeters.

This species is characterized by its medium size, broadly subelliptical outline, and very faint radial sculpture. No other species from the Western Interior is close enough to it to deserve comparison. *N. percrassa* Conrad[2] in the Ripley fauna of the Coastal Plain resembles *N. larimerensis* but the latter has much fainter radial sculpture, is less gibbous and more evenly subelliptical in outline, and has the beaks lower and placed farther forward. *N. larimerensis* also resembles *N. slackiana* Gabb[3] but has again much fainter radial sculpture, lower and more anteriorly placed beaks, and subelliptical outline.

The type is in the U. S. National Museum (Cat. No. 73454).

Nucula weldensis Reeside, n. sp.

Figures 16–18

Five specimens collected by Prof. Johnson from the Fox Hills sandstone in sec. 21 or 22, T. 11 N., R. 68 W., Larimer County, Colorado, are the basis of this species.

Shell small, moderately heavy; subtrigonal, rather inflated; proportion of length to height about as 4 to 3. Beaks not very prominent, posterior, opisthogyrate. Lunule elongate, ill-defined, bordered by an indistinct angulation of the valve; escutcheon nearly smooth, cordate, of moderate size, sharply defined by an angular shoulder. Anterior and posterior margins rounded, basal margin semielliptic in outline, apparently smooth inside. Dorsum declining with moderate convexity anterior to the beaks and with slight concavity behind; gross angle formed by the dorsum at the beaks about 75°.

Sculpture of fine concentric growth lines and only the faintest suggestion here and there of radial sculpture.

Internal characters unknown in type. Cross-section of another specimen indicates a series of 20 teeth before the beak and one of 9 behind, diverging at an angle of 90°.

Length of type, 20 millimeters; height, 15 millimeters; convexity of a valve, 6 millimeters.

This species is characterized by small size; relatively high, subtrigonal, inflated shell; distinct escutcheon; smooth inner margins; and lack of radial

[2] T. A. Conrad. *Observations on a group of Cretaceous fossil shells found in Tippah County, Miss.* Journ. Acad. Nat. Sci. Phila. (2) **3**: 327. *pl. 35, f. 4.* 1856; Bruce Wade. *The fauna of the Ripley formation on Coon Creek, Tenn.* U. S. Geol. Surv. Prof. Paper **137**: 39. *pl. 8, f. 1–4.* 1926.

[3] W. M. Gabb. *Descriptions of new species of American Tertiary and Cretaceous fossils.* Journ. Acad. Nat. Sci. Phila. (2) **4**: 397. *pl. 48, f. 37.* 1860; Julia Gardner. *Md. Geol. Surv. Rept., Upper Cret.,* p. 511. *pl. 19, f. 1–4.* 1916.

sculpture. It differs from the nearest forms of the Western Interior as follows: from *N. planimarginata* Meek and Hayden[4] in its smaller, stouter shell, higher subtrigonal outline, and lack of radial sculpture; from *N. cancellata* Meek and Hayden[5] in smaller size, higher subtrigonal shell, and lack of radial sculpture; from *N. coloradoensis* Stanton[6] in its larger, stouter shell and lack of radial sculpture; from an unnamed species in the Eagle sandstone of Montana in its lack of radial sculpture and smaller escutcheon. *N. weldensis* differs from similar species of the Coastal Plain as follows: from *N. stantoni* Stephenson[7] in its lack of radial sculpture, lesser height, stouter shell, and greater umbonal angle; from *N. amica* Gardner[8] in its lack of radial and strong, regular concentric sculpture; from *N. microconcentrica* Wade[9] in its subtrigonal form.

The type is in the U. S. National Museum (Cat. No. 73455); four paratypes are at the Colorado School of Mines, Golden, Colorado.

Genus OSTREA Linnaeus

Ostrea gillulyi Reeside, n. sp.

Figures 1–6, 10, 11

This species is represented by 6 individuals from 6 localities and a somewhat doubtful lot of 10 specimens from a seventh locality.

Shell of medium size, subovate to subtriangular, more or less arcuate. Shell thin in most specimens, moderately thick in some. Beaks narrow to pointed, slightly twisted, and turned posteriorly. Left valve swollen, rather evenly rounded; right valve flat to slightly concave, fitting within the margins of the left valve.

Hinge high, triangular, sharply inclined posteriorly. Ligament area crossed by fine growth lines and in the right valve by fine longitudinal lines also; groove well-defined, deep. Margins of right valve near the hinge coarsely dentate; of the left valve pitted to correspond with the denticles of the right valve. Muscle scar large, oval, situated toward the middle posterior of the valves. Margins of the lower part of both valves smooth.

Surface of left valve covered by irregular, rounded radial ribs, 2 to 4 millimeters wide, which bifurcate and are variable in height; and by sharp concentric lamellae. Surface of right valve with sharp concentric lamellae and obscure, irregular radial ribs or striae.

The height of the type is 75 millimeters; length, 40 millimeters; convexity of the left valve, 15 millimeters.

[4] F. B. MEEK. *Invertebrate Cretaceous and Tertiary fossils of the Upper Missouri Country.* Rept. U. S. Geol. Surv. Terr. **9**: 101. *pl. 15, f. 8; pl. 28, f. 16.* 1876.

[5] F. B. MEEK. *Op. cit.*, p. 102. *pl. 28, f. 13.*

[6] T. W. STANTON. *The Colorado group and its invertebrate fauna.* U. S. Geol. Surv. Bull. **106**: 94. *pl. 21, f. 9.* 1893.

[7] L. W. STEPHENSON. *Cretaceous formations of North Carolina.* Rept. N. Car. Geol. Econ. Surv. **5(1)**: 79. *pl. 11, f. 1–6.* 1923.

[8] JULIA GARDNER. *Op. cit.*, p. 514. *pl. 19, f. 5–6.*

[9] BRUCE WADE. *Op. cit.*, p. 40. *pl. 8, f. 7–8.*

This species is characterized by its strong radial sculpture, somewhat arcuate form, and its size. No species now known in the Western Interior is very close to it. In the Coastal Plain *O. tecticosta* Gabb[10] is similar but seems a consistently smaller, less arcuate, and more coarsely ribbed shell. Some Tertiary species also are similar to *O. gillulyi* but hardly enter into consideration here.

The type specimen (U. S. Nat. Mus. Cat. No. 73457) was collected by James Gilluly from the Fox Hills sandstone in the NW 1/4 sec. 7, T. 9 N., R. 67 W., Weld County, Colorado. Other specimens (U. S. Nat. Mus. Cat. No. 73456) from the Fox Hills of Colorado were collected by Prof. Johnson in sec. 21 or 22, T. 11 N., R. 68 W., Larimer County. It is also represented in a collection made by V. H. Barnett from the top of the Lewis shale in the SW 1/4 sec. 34, T. 34 N., R. 77 W., Converse County, Wyoming; in a collection made by C. E. Dobbin from the lower part of the Lewis shale in NW 1/4 sec. 8, T. 21 N., R. 78 W., Carbon County, Wyoming. A collection made by T. W. Stanton from the Mesaverde formation at James Lake, Laramie Plains, Albany County, Wyoming, contains a number of specimens of an oyster that appears to be this species, though all the individuals are small and none are especially well preserved. The range of *O. gillulyi* would appear to be through the upper half of the Montana group.

Genus Gyrodes Conrad

Gyrodes johnsoni Reeside, n. sp.

Figures 12–15

Three specimens from the Fox Hills sandstone in sec. 21 or 22, T. 11 N., R. 68 W., Larimer County, Colorado, collected by Prof. Johnson, are the basis of this species.

Shell small for the genus, very much depressed, approaching a thick disk in general form. Volutions about 3 in number, the outer one constituting perhaps three-fourths of the bulk of the shell; well rounded in cross-section, showing neither shoulder nor umbilical carina. Surface of the shell in part preserved in the type and showing only lines of growth parallel to the aperture. Suture impressed. Aperture obliquely ovate; outer lip thin, sharp; inner lip thin, nearly straight. Umbilicus deep, open.

Maximum diameter of shell, 21 millimeters; altitude, 14 millimeters.

This species is distinguished from most species of *Gyrodes* by the lack of shoulder and umbilical carination, from others by the great depression of the whorls. *G. petrosa* Morton[11] and *G. depressa* Meek[12] are perhaps the nearest species but both have an umbilical carina and are relatively higher shells.

[10] W. M. Gabb. *Op. cit.*, p. 403. *pl. 68, f. 47–48;* L. W. Stephenson. *Op. cit.*, p. 143. *pl. 38, f. 1–9.*

[11] Stuart Weller. *Cretaceous paleontology of New Jersey.* N. J. Geol. Surv., Pal. ser. **4**: 689. *pl. 77, f. 13–18.* 1907.

[12] T. W. Stanton. *Op. cit.*, p. 135, *pl. 29, f. 11–14.*